DESCRIPTION

HOLOGRAPHIC MEMORY REPRODUCTION METHOD AND APPARATUS

TECHNICAL FIELD

5   This invention relates to a holographic memory

reproduction method and apparatus.

BACKGROUND ART

       For example, in Japanese Patent Laid-Open Publication No.

10   2003-85768, an optical information recording apparatus and

method have been disclosed in which servo control in a moving

direction of an optical information recording medium is

performed by detecting a positional deviation between an

optical head and at least one lockup pit arranged in an

15   information recording area, whereby an information beam and a

reference beam for recording are continuously and accurately

projected onto an information recording position without

causing positional deviation during hologram recording to

thereby record holograms in the optical information recording

20   medium.

       In this case, the lockup pit arranged in the information

recording area is an area on which holographic recording

cannot be performed.

       As described above, in the optical information recording

25   apparatus and method disclosed in Japanese Patent Laid-Open

Publication No. 2003-85768, the lockup pit serving as the

reference for the servo control is an area on which

holographic recording cannot be performed. Therefore, problems

arise that the data capacity of the recording medium is

5 reduced by an amount corresponding to the area of the

abovementioned lockup pit, and that the number of

manufacturing steps for forming the lockup pit increases or

noise in a data beam increases.

10 DISCLOSURE OF THE INVENTION

        This invention has been made in view of the

abovementioned problems. Accordingly, it is an object of the

invention to provide a holographic memory reproduction method

and apparatus in which data capacity is reduced and in which

15 extra processing for a lockup pit or the like is not required

in a servo layer.

        The present inventor has made intensive studies and has

consequently found that reproduction position servo-control

can be performed by projecting, onto interference fringes

20 formed in a recording layer of a holographic recording medium,

a servo beam which satisfies the Bragg condition while at

least one of the wavelength, incident angle, and incident

direction thereof is different from that of a reproduction

beam.

25   In summary, the above-described objectives are achieved

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by the following aspects of the present invention.

(1) A holographic memory reproduction method, wherein, when a diffraction beam is generated in a recording layer of a holographic recording medium by projecting a reproduction beam onto interference fringes formed by projecting an object beam and a reference beam onto the recording layer to thereby reproduce information from this diffraction beam, a servo beam which satisfies the Bragg condition while at least one of the wavelength, incident angle, and incident direction thereof is different from that of the reproduction beam is projected onto the interference fringes, whereby the reproduction position servo-control of the holographic recording medium is performed by means of the diffraction beam generated by the projection of the servo beam.

(2) The holographic memory reproduction method according to (1), wherein the servo beam is projected along a projection optical axis of the object beam and the direction opposite to that of the object beam.

(3) The holographic memory reproduction method according to (1), wherein the servo beam is projected along a projection optical axis of the object beam and the direction the same as that of the object beam.

(4) The holographic memory reproduction method according to (1), wherein the servo beam is projected along a projection optical axis of the reference beam and the direction the same

as that of the reference beam.

(5) The holographic memory reproduction method according to (1), wherein the servo beam is projected along a projection optical axis of the reference beam and the direction opposite

5   to that of the reference beam.

(6) The holographic memory reproduction method according to any one of (1) to (5), wherein the servo beam is a plane wave having a beam diameter of 1/100 to 1/10 of the beam diameter of one of the object beam, the reference beam, and

10   the reproduction beam.

(7) The holographic memory reproduction method according to (6), wherein at least one of the object beam and the reference beam is a non-collimated beam, and the interference fringes are formed through spherical waves.

15   (8) The holographic memory reproduction method according to any one of (1) to (7), wherein the servo beam is projected from a beam source different from that for the reproduction beam.

(9) The holographic memory reproduction method according

20   to any one of (1) to (7), wherein the servo beam is projected by splitting part of the reproduction beam.

(10) The holographic memory reproduction method according to any one of (1) to (9), wherein shift multiplex recording is performed two-dimensionally on the holographic recording

25   medium, and two-dimensional reproduction position servo-

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control is performed on the holographic recording medium by means of the diffraction beam generated by the projection of the servo beam.

(11) A holographic memory reproduction apparatus in which a diffraction beam is generated in a recording layer of a holographic recording medium by projecting a reproduction beam onto interference fringes formed by projecting an object beam and a reference beam onto the recording layer to thereby reproduce information from this diffraction beam, the apparatus comprising a servo optical system in which a servo beam which satisfies the Bragg condition while at least one of the wavelength, incident angle, and incident direction thereof is different from that of the reproduction beam is projected onto the interference fringes, whereby the reproduction position servo-control of the holographic recording medium is performed by means of the diffraction beam generated by the projection of the servo beam.

(12) The holographic memory reproduction apparatus according to (11), wherein the servo optical system is configured such that the servo beam is projected along a projection optical axis of the object beam and the direction opposite to that of the object beam.

(13) The holographic memory reproduction apparatus according to (11), wherein the servo optical system is configured such that the servo beam is projected along a

projection optical axis of the object beam and the direction

the same as that of the object beam.

(14) The holographic memory reproduction apparatus

according to (11), wherein the servo optical system is

5   configured such that the servo beam is projected along a

projection optical axis of the reference beam and the

direction the same as that of the reference beam.

(15) The holographic memory reproduction apparatus

according to (11), wherein the servo optical system is

10   configured such that the servo beam is projected along a

projection optical axis of the reference beam and one of the

direction opposite to that of the reference beam.

(16) The holographic memory reproduction apparatus

according to any one of (11) to (15), wherein the servo

15   optical system is configured such that the servo beam is a

plane wave having a beam diameter of 1/100 to 1/10 of the beam

diameter of one of the object beam, the reference beam, and

the reproduction beam.

(17) The holographic memory reproduction apparatus

20   according to any one of (11) to (16), wherein shift multiplex

recording is performed two-dimensionally on the holographic

recording medium, and the servo optical system is configured

such that two-dimensional reproduction position servo-control

is performed on the holographic recording medium by means of

25   the diffraction beam generated by the projection of the servo

beam.

(18) The holographic memory reproduction apparatus according to any one of (11) to (17), wherein the servo optical system comprises a servo beam source which emits the

5 servo beam different from the reproduction beam.

(19) The holographic memory reproduction apparatus according to any one of (11) to (17), wherein the servo optical system comprises a reproduction beam splitting apparatus which forms the servo beams by splitting part of the

10 reproduction beam.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is an optical system diagram illustrating a holographic recording and reproducing apparatus according to a

15 first embodiment of the present invention.

Fig. 2 is an enlarged optical system diagram illustrating a part of a servo optical system in the first embodiment.

Fig. 3 is a diagram showing the relationship between the projection position of a servo beam and the diffraction

20 efficiency of the servo beam in the first embodiment.

Fig. 4 is a diagram illustrating the relationship among the projection position of the servo beam, interference fringes, and a diffraction beam in the first embodiment.

Fig. 5 is a diagram illustrating the relationship between

25 a large diameter servo beam and a diffraction beam.

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Fig. 6 is a diagram showing the relationship among the beam diameter of the servo beam, the projection position of the servo beam, and the diffraction efficiency of the servo beam.

5   Fig. 7 is an optical system diagram illustrating a holographic recording and reproducing apparatus according to a second embodiment of the present invention.

Fig. 8 is an optical system diagram illustrating a holographic recording and reproducing apparatus according to a

10   third embodiment of the present invention.

Fig. 9 is an enlarged cross-sectional view schematically illustrating the relationship among the holographic recording medium, the servo beam, and the diffraction beam in a fourth embodiment of the present invention.

15   Fig. 10 is an enlarged cross-sectional view schematically illustrating the relationship among the holographic recording medium, the servo beam, and the diffraction beam in a fifth embodiment of the present invention.

Fig. 11 is an enlarged cross-sectional view schematically

20   illustrating the relationship among the holographic recording medium, the servo beam, and the diffraction beam in a sixth embodiment of the present invention.

Fig. 12 is a plan view schematically illustrating a method of a seventh embodiment in which reproduction position

25   servo-control of shift-multiplex-recorded-holograms is

performed in an X-axis direction and a Y-axis direction.

Fig. 13 is a diagram illustrating the relationship among the moving direction of the holographic recording medium, the centers of a recording spot in the X-axis direction and the Y-

5   axis direction, and diffraction efficiency in the seventh embodiment.

Fig. 14 is a diagram illustrating a quadrant detector employed in an eighth embodiment in which reproduction position servo control is performed in the X-axis direction

10   and the Y-axis direction and also showing the diffraction efficiency of a diffraction beam in relationship to a recording spot.

BEST MODE FOR CARRYING OUT THE INVENTION

15   A beam which is part of a reproduction beam projected onto a holographic recording medium and has passed through the holographic recording medium is reflected by a mirror and is then projected onto the holographic recording medium, and the diffraction beam therefrom is extracted as a servo beam. By

20   detecting the servo beam, reproduction position servo-control is performed.

[First Embodiment]

Next, a first embodiment will be described with reference to Figs. 1 and 2.

25   A holographic recording and reproducing apparatus 10

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according to the first embodiment is configured to include: a

laser beam source 12; a beam expander 14 for expanding the

beam diameter of a laser beam emitted from the laser beam

source 12; a polarizing beam splitter 16 which splits the

5 laser beam having the beam diameter expanded by this beam

expander 14 into a p-polarized beam and an s-polarized beam; a

reference optical system 20 which guides the p-polarized beam

having passed through this polarizing beam splitter 16 to a

holographic recording medium 18 as a reference beam; an object

10 optical system 22 which guides the s-polarized beam having

been reflected by the polarizing beam splitter 16 to the

abovementioned holographic recording medium 18 as an object

beam; an imaging optical system 24 which is provided on the

optical axis of the object beam projected onto the holographic

15 recording medium 18 via this object optical system 22 and is

arranged on the side opposite to the holographic recording

medium 18; and a servo optical system 26 which projects the

servo beam onto the abovementioned holographic recording

medium 18 and receives the diffraction beam thereof to perform

20 reproduction position servo-control.

The abovementioned reference optical system 20 is

configured to include a mirror 20A and an objective lens 20B

in this order from the side of the polarizing beam splitter 16.

Moreover, the object optical system 22 is configured to

25 include a 1/2 wave plate 22A, a spatial light modulator 22B, a

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mirror 22C, and a Fourier lens 22D in this order from the side of the polarizing beam splitter 16.

The imaging optical system 24 is configured to include an imaging lens 24A and an imaging device 24B on which an image of the diffraction beam from the abovementioned holographic recording medium 18 is formed via this imaging lens 24A, in this order from the side of the holographic recording medium 18.

Moreover, the servo optical system 26 is configured to include: a concave mirror 26A provided on a line extending the optical axis of the reference beam from the reference optical system 20 and passing through the holographic recording medium 18; a polarizing beam splitter 26B provided on the optical axis of the object beam between the Fourier lens 22D in the abovementioned object optical system 22 and the holographic recording medium 18; and a photodetector 26C provided on the optical axis of a reflection beam which is reflected orthogonally from the polarizing beam splitter 26B after traveling along the optical axis of the object beam from the abovementioned holographic recording medium 18 toward the polarizing beam splitter 26B. The abovementioned polarizing beam splitter 26B is designed to reflect the s-polarized beam and to allow the p-polarized beam to pass through.

Further, the abovementioned concave mirror 26A is designed such that, when the reproduction beam is incident on

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the holographic recording medium 18 in a similar manner as that of the reference beam, the transmission beam thereof is reflected in the opposite direction along the optical axis of the reproduction beam, and such that, at this time, the beam

5   diameter of the reflection beam becomes 1/100 to 1/10 of the beam diameter of the reference beam (this may be the object beam or the reproduction beam) expanded by the abovementioned beam expander 14.

First, a description will be given of a process of

10 recording information in the holographic recording medium 18 by means of the abovementioned holographic recording and reproducing apparatus 10.

The beam diameter of the laser beam from the laser beam source 12 is expanded by the beam expander 14. This laser beam

15 is split into a p-polarized beam which is a transmission beam and an s-polarized beam which is a reflection beam by the polarizing beam splitter 16. The p-polarized beam and the s-polarized beam enter the reference optical system 20 and the object optical system 22, respectively.

20   In the reference optical system 20, the reference beam is reflected by the mirror 20A, is converted to a spherical wave through the objective lens 20B, and is then projected onto the holographic recording medium 18.

On the other hand, in the object optical system 22, the

25 phase of the s-polarized beam serving as the object beam is

shifted by the 1/2 wave plate 22A to form a p-polarized beam, and the data to be recorded is provided to this beam at the spatial light modulator 22B. The beam is then reflected by the mirror 22C, is converted to a spherical wave through the

5   Fourier lens 22D, and is projected onto the holographic recording medium 18.

Both the reference and object beams projected onto the holographic recording medium 18 are a p-polarized beam and pass through the same area in a recording layer 18A to thereby

10   form optical interference fringes. Hence, the abovementioned provided data is recorded in the holographic recording medium 18.

When the information (data) in the holographic recording medium 18 is reproduced, the object beam is blocked by the

15   spatial light modulator 22B, and the reference beam is employed as the reproduction beam and is projected onto the holographic recording medium 18.

When the reproduction beam is projected onto the recording layer 18A of the holographic recording medium 18, a

20   diffraction beam is generated by the interference fringes therein. This diffraction beam forms an image on the imaging device 24B through the imaging lens 24A, and the abovementioned data is reproduced based on the information obtained by the imaging device 24B.

25   Most of the abovementioned reproduction beam is not

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diffracted by the holographic recording medium 18 and is incident on the concave mirror 26A of the abovementioned servo optical system 26 as a transmission beam. The abovementioned reproduction beam passes through the holographic recording

5   medium 18. After passing through a focal point, the reproduction beam is projected onto the concave mirror 26A as a diverging spherical wave and is reflected in the opposite direction toward the holographic recording medium 18 as a collimated plane wave.

10   At this time, the beam diameter of the reflected beam is reduced, and this beam is projected onto the holographic recording medium 18 from the direction opposite the reproduction beam. In the holographic recording medium 18, a servo beam is generated which is a diffraction beam in the

15   direction opposite the abovementioned object beam.

        This servo beam is reflected by the abovementioned polarizing beam splitter 26B and is incident on the photodetector 26C.

        Here, since the polarizing beam splitter 26B of the

20   abovementioned servo optical system 26 is designed to allow a p-polarized beam to pass through, the object beam is not reflected by this polarizing beam splitter 26B.

        The diffraction efficiency of the beam reflected by the abovementioned concave mirror 26A (the servo beam) largely

25   varies in the abovementioned recording layer 18A depending on

the projection position of the servo beam as shown in Fig. 3. The pitch of the peaks of the diffraction efficiency is the same as the shift amount pitch P (the distance between the centers of the adjacent holograms) of the interference fringes

5   which are shift-multiplex-recorded.

This is because, if the interference fringes are formed through spherical waves as shown in Fig. 4, the diffraction beam is generated only at the moment at which the optical axis of the servo beam is coincident with a reference beam axis Res

10   (i.e., the Bragg condition is satisfied), as shown by a solid line in Fig. 4, during the lateral translational motion (the relative motion) of the holographic recording medium 18 with respect to the servo beam having a small beam diameter. As shown by a long dashed short dashed line and a long dashed

15   double-short dashed line, if the optical axis of the servo beam deviates from that of the reference beam, the diffraction beam is not generated since the incident angle of the servo beam is different from that of the reference beam for the interference fringes in the region through which the servo

20   beam passes (i.e., the Bragg condition is not satisfied).

Therefore, by detecting the diffraction beam generated only at the moment at which the optical axis of the servo beam is coincident with the reference beam axis as mentioned above by means of the photodetector 26C, a reproduction position can

25   be servo-controlled to the position at which the output signal

thereof has a peak value.

On the contrary to the above, for example, in the case where a servo beam Seb having a beam diameter larger than the sift selectivity of the holograms is projected as shown in Fig. 5, only a partial light beam around the optical axis of the servo beam is diffracted even when the optical axis of the servo beam Seb is coincident with the reference beam axis Res, and part of the servo beam away from the optical axis (by the shift selectivity or larger) passes through.

Hence, the peak value of the diffraction efficiency is smaller than that of the servo beam having a small beam diameter. Further, even when the optical axis of the servo beam deviates slightly from that of the reference beam, a permissible width with respect to the positional deviation of the servo beam (from the reference beam) becomes larger since a partial light beam around the portion coincident with the reference beam axis is diffracted.

Fig. 6 is a diagram illustrating this case. In Fig. 6, a solid line represents the case where the beam diameter of the servo beam is small, and a dashed line represents the case where the beam diameter of the servo beam is large.

As can be seen from Fig. 6, if the beam diameter of the servo beam is increased, the separation and detection of holographic recording is difficult. On the contrary, if the beam diameter is too small, the optical system therefor

becomes complicated. Thus, it is preferable that the optimum

value of the beam diameter of the servo beam be 1/100 to 1/10

of the beam diameter of the reproduction beam.

[Second Embodiment]

5   In the first embodiment above, the transmission beam of

the reproduction beam serves as the servo beam, and the

reproduction beam and the servo beam have the same wavelength.

However, if the servo beam having the same length as that of

the reproduction beam is employed, the first embodiment is not

10   restrictive. A servo beam source provided separately from the

laser beam source 12 may be employed.

In a holographic recording and reproducing apparatus 30

according to a second embodiment shown in Fig. 7, a servo

optical system 32 is constituted by: a laser diode (a servo

15   beam source) 32A provided on a line extending the optical axis

of the reference beam in the holographic recording and

reproducing apparatus 10 of Fig. 1 and passing through the

holographic recording medium 18; a collimating lens 32B which

shapes a laser beam from this laser diode 32A; and the

20   polarizing beam splitter 26B and photodetector 26C the same as

those provided in the servo optical system of the holographic

recording and reproducing apparatus 10 of the abovementioned

first embodiment.

The laser diode 32A serving as a servo beam source is

25   designed to emit a laser beam having the same wavelength as

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that of the beam emitted from the laser beam source 12.

The rest of the configuration of the holographic recording and reproducing apparatus 30 is the same as that of the holographic recording and reproducing apparatus 10 of the

5   first embodiment. Thus, the same numerals as those employed in the configuration of Fig. 1 are used, and the descriptions will be omitted.

In the second embodiment, the laser beam emitted from the laser diode 32A is shaped by the collimating lens 32B and is

10   projected onto the holographic recording medium 18 as a servo beam. In the holographic recording medium 18, a diffraction beam serving as the servo beam is generated on the optical axis of the object beam, is reflected by the polarizing beam splitter 26B, and is received by the photodetector 26C.

15   In the first and second embodiments, when information is recorded in the holographic recording medium 18, the polarizing beam splitter 26B in the abovementioned servo optical systems 26 and 32 is unnecessary. Therefore, the polarizing beam splitter 26B may be evacuated from the object

20   optical system 22 upon recording and inserted onto the optical path of the object beam upon reproduction.

In such a manner, an ordinary beam splitter may be employed in place of the polarizing beam splitter. Further, since the object optical system 22 is blocked upon

25   reproduction, a total reflection mirror may be employed.

[Third Embodiment]

In the servo optical system of the first and second embodiments, the servo beam has the same wavelength as that of the reproduction beam and is projected onto the holographic

5   recording medium along the optical axis of the reproduction beam from the direction opposite the reproduction beam, but the present invention is not limited thereto. The servo beam may be any beam which satisfies the Bragg condition in the interference fringes while at least one of the wavelength,

10   incident angle, and incident direction thereof is different from that of the reproduction beam.

The third embodiment shown in Fig. 8 is the case where a servo beam having a wavelength different from that of the reproduction beam is employed. In a holographic recording and

15   reproducing apparatus 40 according to the third embodiment, a servo optical system 42 is provided which projects the servo beam from the side opposite to the side of the reproduction beam (the reference beam) and a direction different from that of the optical axis of the reproduction beam. The rest of the

20   configuration of this holographic recording and reproducing apparatus 40 is the same as the configuration of the holographic recording and reproducing apparatus 10 of the first embodiment, except that the 1/2 wave plate 22A is not provided. Thus, the same numerals as those employed in the

25   configuration of Fig. 1 are used, and the descriptions will be

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omitted.

The servo optical system 42 is configured to include: a servo beam source 42A which projects a servo beam having a wavelength different from that of the reproduction beam onto the holographic recording medium 18 at an incident angle different from that of the reproduction beam; a photodetector 42B which receives a diffraction beam generated by the projection; and a collimating lens 42C.

The relationship between the wavelength of the laser beam emitted from the abovementioned servo beam source 42A and the incident angle to the holographic recording medium 18 is set such that the Bragg condition is satisfied in the interference fringes in the recording layer 18A.

In the third embodiment, the servo beam is not coaxial with the reproduction beam, the reference beam, and the object beam. Therefore, it is possible to prevent the occurrence of problems including: undesirable mutual interference between coaxial beams, such as the generation of noise in a reproduction image due to multiple reflections of the servo beam from a lens or the like; and the occurrence of beam source noise and damage to a laser beam source when the servo beam enters a laser for recording and reproducing.

When the wavelength of the reproduction beam is largely different from that of the servo beam, the distribution of optimal optical components may not be compatible with an

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antireflection coating or the like, or some additional cost

may be required for providing beam sources for different

wavelengths. Thus, the wavelength difference between the

reproduction beam and the servo beam may be determined by

5   taking into account the abovementioned properties and cost.

[Fourth Embodiment]

Each of fourth to sixth embodiments shows the case where

the servo beam is projected along the optical axis of the

reference beam or the object beam from the direction the same

10   as or opposite to that of the object beam or the reference

beam.

In the fourth to sixth embodiments, the relationship

among the holographic recording medium 18 and the reproduction

and diffraction beams therearound is enlarged and shown, and

15   the rest of the configuration is omitted.

In the fourth embodiment in Fig. 9, the servo beam SE is

incident on the holographic recording medium 18 along the

optical axis Obs of the object beam upon recording and the

direction opposite the object beam, and the diffraction beam

20   RE is obtained along the optical axis Res of the reference

beam and the direction opposite the reproduction beam.

[Fifth Embodiment]

In the fifth embodiment in Fig. 10, the servo beam SE is

incident along the optical axis Res of the reproduction beam

25   (the reference beam) and the direction same as that of the

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reproduction beam, and the diffraction beam RE thereof is obtained along a line extending the optical axis Obs of the object beam.

[Sixth Embodiment]

5   In the sixth embodiment in Fig. 11, the servo beam SE is incident along the optical axis Obs of the object beam and the same direction as that of the object beam, and the diffraction beam RE is obtained along a line extending the optical axis Res of the reference beam.

10   [Seventh Embodiment]

       Next, a description will be given of a case in which reproduction servo-control is performed in an X-axis direction and a Y-axis direction during the reproduction of a holographic recording medium 50 on which shift multiplex shift

15   recording has been performed two-dimensionally (in the X-axis and Y-axis directions) as shown in Fig. 12.

       For convenience of description, the X-axis is defined as the line of intersection of a recording surface of the holographic recording medium 50 with an incident plane of the

20   object beam and the reference beam, and the Y-axis is defined as the direction included in the recording surface and orthogonal to the X-axis.

       According to the principle of shift multiplex recording, selectivity in the Y-axis direction is lower than that in the

25   X-axis direction. That is, assuming that the minimum pitch

necessary for separating adjacent unit recording spots Ms is

ΔX and ΔY, $\Delta X < \Delta Y$, as shown in Fig. 12.

The absolute value of the abovementioned pitch depends on

optical systems to be employed and the thickness of a

5   recording medium. For example, for a recording medium having a

thickness of 1 mm, ΔX is 1 to 10 μm, and ΔY is several tens to

several hundreds of μm. (However, for a reflection type

hologram in a polarizing collinear method in which an X-axis

and a Y-axis cannot be defined (are equivalent), the

10   selectivity can be set such that both ΔX and ΔY are

approximately 1 to approximately 10 μm.

Here, when the holographic recording medium 50 is

translated in the X-axis direction while a servo beam which is

narrow to the extent that the selectivity works (has a small

15   beam diameter) is projected thereonto at the same incident

angle as that of the optical axis of the reference beam, a

diffraction beam emerges or is intensified only when this

servo beam is nearly coincident with the optical axis of the

reference beam upon recording. Hence, reproduction position

20   servo-control can be performed in the X-axis direction. At the

same time, since similar selectivity works for the positional

deviation in the Y-axis direction, position servo-control

(corresponding to a tracking action for an optical disc) in

the Y-axis direction is also possible).

25   [Eighth Embodiment]

In an apparatus for performing the reproduction position

servo-control in the X-axis and Y-axis directions in the

method of the seventh embodiment, for example, a quadrant

detector 60 is employed as in an eight embodiment shown in Fig.

5   14. In this quadrant detector 60, a servo beam detection area

shown in Fig. 14 is constituted by 1/4 circular split

detection areas 62A to 62D each of which detects the servo

beam. In addition, based on the detected detection beam

intensity signal, a computation is performed in a computing

10   unit 64 to determine a reproduction point in the X- and Y-axis

directions.

Here, the detected optical intensities of the

abovementioned split detection areas 62A to 62D are assumed to

be A to D, respectively, and the computation is performed by

15   use of the following equations (1) to (3). For the position

servo-control for the translational motion in the X-axis

direction, since the center of the split detection areas 62A

to 62D is coincident with the center of the recording spot Ms

at the moment when (RF - sum) is maximum and (PP - X) is zero,

20   this may be employed as the reproduction point.

$$(RF - sum) = A + B + C + D \qquad (1)$$

$$(PP - X) = (B + C) - (A + D) \qquad (2)$$

$$(PP - Y) = (C + D) - (A + B) \qquad (3)$$

In addition, for the positional deviation in the Y-axis

25   direction, the holographic recording medium 50 is moved

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downward in Fig. 14 when (PP − Y) is negative, and is moved

upward when (PP − Y) is positive.

This eighth embodiment has an advantage that the

direction of the deviation of the servo beam (the diffraction

5   beam) from the center of the recording spot Ms can be found

when the servo beam is not obtained.

In each of the abovementioned embodiments, a description

has been given of the case where holographic recording is

performed on the holographic recording medium and the

10   apparatus for reproducing the recorded information (memory) is

employed. However, the present invention is applied to a

reproduction part of the holographic recording and reproducing

apparatus and thus is, of course, applied to a holographic

memory reproducing method and apparatus for reproduction only.

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INDUSTRIAL APPLICABILITY

In this invention, the servo beam which is separable from

the reproduction beam is projected onto the recording layer in

which the interference fringes are formed to thereby perform

20   the reproduction position servo-control. Therefore, since a

lockup pit area or the like for the reproduction position

servo-control is not required to be provided, the data

capacity of the recording medium can be increased. In addition,

the manufacturing process can be shortened, and noise to the

25   reproduction beam can be reduced.